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NOTES FROM PACIFIC COAST OBSERVATORIES

THE AURORA BOREALIS OF MAY 14, 1921

An unusually brilliant aurora borealis was observed here on Saturday evening, May 14. The newspapers report that the aurora was widely observed thruout the United States, and that its effects were also noted on the North Atlantic Ocean and in Great Britain.¹ The area of visibility was probably still more extensive. The spectacle was almost unique for native Californians, as aurorae are conspicuous here only at rare intervals. None approaching the present one in intensity has been observed at Mount Hamilton since the year 1894, when several aurorae of varying degrees of brilliancy were visible.

The nature and cause of aurorae are still obscure, but their effects upon terrestrial conditions are well known to telegraphers and magnetic observers. Brilliant aurorae are probably without exception accompanied by magnetic disturbances which seem to indicate an electrified state of our atmosphere. Long distance telegraphing is seriously interfered with and frequently stopped altogether for hours at a time. On the present occasion, at the maximum of auroral activity, telegraphic communication was still possible between points in California several hundreds of miles apart, but trans-continental messages could not be forwarded. Some newspapers reported that the sending of wireless messages was not interrupted and was even assisted, whereas other reports were to the effect that along the stretch of coast between Oregon and Alaska there was serious interference; but these reports should not be given credence without verification.

The aurora was visible at Mount Hamilton as soon as the evening sky was dark. Maxima of activities were reached about 9:40 and 11:15, Pacific Standard Time; the display after midnight was relatively feeble. In the early evening the sky illumination was strong even with the half-full Moon at considerable altitudes. The more intense parts of the display were confined to the northern third of the sky. A long strip several degrees wide, roughly parallel to the northern horizon, but approximately three to seven degrees above

¹Mr. Charles Butterworth, of Portland, Oregon, in a letter sent to the Lick Observatory, states that an auroral display was seen there on Friday evening, May 13, the maximum occurring at 10 P. M. "Relatively permanent arc of illumination reached to 45° to 50° above the horizon; center due north (not northeast toward magnetic pole). This arc characterized by rapid formation of bright greenish white 'clouds' 5° to 10° in diameter. The shafts of colored light generally passed beyond this arc, disappearing near the zenith."

the horizon, was quite persistent. Irregular areas, strongly illuminated, were variously located above this band, some of them near the zenith and others in widely different parts of the sky. Brilliantly illuminated tufts, cloudlike in form, would suddenly appear even in the low southwestern and southeastern sky, and as suddenly disappear. At times of greatest activity streamers rapidly changing in length, form and position, extended up from the bright northern band described above. Those streamers whose lower extremities were in the direction of the north magnetic pole were directed to the zenith. Those whose lower ends were well to the west of the magnetic pole were directed to points far to the west of the zenith, in some cases toward points whose altitudes above the western horizon were only thirty, forty and fifty degrees (by estimation). Streamers to the east of the magnetic meridian were not prominent.

The green auroral spectrum line was always conspicuous, as viewed thru a small direct-vision spectroscope. When the activity was the greatest a red line, a blue line and a violet line were also plainly visible. Unfortunately, it was not practicable to photograph the spectrum, as the Observatory was overwhelmed with public visitors until 10:30 P. M., and portable spectrographs were not at the time available.

The auroral light has its origin, so far as the Earth is concerned, in the higher strata of our atmosphere. The brilliant streamers and cloudlike forms are usually at an altitude of one hundred kilometers or more above the Earth's surface. Their heights have been measured on many occasions by two observers noting the directions of well-defined and mutually identified points simultaneously. Knowing the relative positions of the two observing stations, the computation of the altitudes is a simple problem in trigonometry. Störmer of the University of Christiania is entitled to great credit for marking extensive locations of aurorae in the higher atmosphere, as to altitude, latitude and longitude. Störmer has found, for Northern Norway at least, that there is a very strong preference for the altitudes lying between ninety and one hundred and twenty kilometers, with maximum preference at one hundred kilometers. A few of the auroral details have apparently been as high as three hundred kilometers. The density of the Earth's atmosphere where the highest aurorae were located is certainly less than one-billionth the density at sea level.

A positive statement as to the origin of the aurorae is not justified, tho there seems to be no reason to doubt that the phenomenon is due to electric discharges in the higher atmosphere. It is well known that auroral activity varies with the sun-spot activity. The actuating force therefore resides in the Sun. The favorite hypothesis of auroral origin, at least during the past two decades, has been that electrically charged particles, exceedingly minute in size, are ejected by the Sun at times of great disturbances in the solar atmosphere, with effective speeds amounting to several thousand miles per second. If the conditions of local activity on the Sun are such that a rich discharge of electrified particles is directed toward the Earth these particles will, after an interval of several hours, reach our atmosphere's higher strata and there produce an electrified state. There is some evidence that these ejected particles are negatively charged. In other cases they seem to bear positive charges, and again the evidence suggests that the terrestrial bombardment is due to the sending out of so-called α radio-active particles from the Sun. It should also be said that there are physicists who reject this corpuscular hypothesis and favor the alternative that magnetic conditions on the Sun produce related electrical conditions in the Earth's atmosphere by induction.

Whatever the nature of the influence to which the Earth is subjected, the observed phenomena are controlled to a considerable extent by the magnetic field of the Earth. Aurorae are most frequently seen in the regions surrounding the north magnetic and the south magnetic poles of the Earth. The north magnetic pole, it is well known, is northwest of Hudson Bay in approximate longitude 97° west and latitude 70° north; that is, about 1400 miles from the Earth's geographic north pole. The aurorae are frequent and brilliant in Central and Eastern Canada, but somewhat less conspicuous in our northeastern states. California is apparently too far from the north magnetic pole to be favored with many intense displays. Antarctic explorers and sailors have described similar displays in Antarctica, which are likewise arranged with reference to the south magnetic pole. Distance from magnetic pole seems not to be the whole factor. Aurorae are very brilliant and numerous in Norway and Sweden and other regions of high latitude which are as far from the north magnetic pole as we are.

The auroral streamers are undoubtedly controlled by the Earth's magnetic field. They seem to lie along the magnetic lines of force.

The chemical elements represented in the spectrum of the aurora have not been identified with certainty. A few of the fainter bright lines seem to have their origin in electric discharges thru rarefied nitrogen. It has been suggested that the strong green line has its origin in krypton, one of the rarer elements in the atmosphere. However, krypton is a heavy gas and its existence at the extreme altitudes of auroral displays could scarcely be expected. Again, that one krypton line should be represented so intensively and other krypton lines not at all are circumstances unfavorable to the krypton hypothesis.

Altho auroral displays are seldom observable in California, it should be said that a feeble auroral light seems to cover our entire sky at all times. In 1894 I found that the green line of the auroral spectrum could be observed at Mount Hamilton on any night in any part of the sky. This observation was later confirmed by Fath and others at Mount Hamilton, and by Slipper at the Lowell Observatory. If electrically charged particles in great numbers travel from the Sun to the Earth at times of brilliant displays it must be considered probable that such particles in reduced numbers are travelling from the Sun to the Earth at all times. However, this is mere hypothesis for the present, and not established fact.

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ON CHANGES OBSERVED IN THE NUCLEUS OF THE SPIRAL NEBULA
N.G.C. 4254 (MESSIER 99)

Changes in the form and structure of the nucleus of the spiral nebula M 99 (N.G.C. 4254, R.A. $12^{\text{h}}13^{\text{m}}.7$; Decl. $+14^{\circ}59'$) were recently detected on the series of photographs of long and short exposures taken with the 40-inch Lowell reflector. As in the case of the earlier observations of the "Crab" nebula (M 1) the possible small changes noted in past years in pairs of plates of different epochs were looked upon as doubtful. In the preceding number of these PUBLICATIONS an account has been given of some of the changes discovered in M 1. The photographs of M 99 taken the present year led to a careful re-examination and intercomparison of all the available plates, and it was found that the nucleus of this nebula varies both in form and in structure. The changes in question are small. There may be a slight variability in the light of the nucleus but I consider the observations uncertain on that point.